

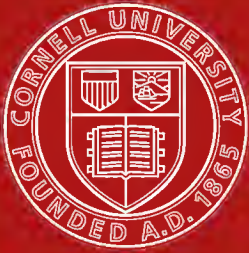
28
157
576

Cornell University Library
QK 757.S96

The effects of radio-active ores and res



3 1924 000 666 119 mann



Cornell University
Library

The original of this book is in
the Cornell University Library.

There are no known copyright restrictions in
the United States on the use of the text.

The
Effects of Radio-Active Ores and
Residues on Plant Life.

By MARTIN H. F. SUTTON, F.L.S.



COPYRIGHT

A view of some of the Trials with Radio-active Ores at Sutton's Experimental Station, Reading.

The immense value of Radium in the treatment of certain forms of disease having already been established, suggestions have been made from time to time that its remarkable properties might also prove beneficial in the promotion of plant life.

In the "Journal of the Royal Society of Arts" for December 12, 1913, there appeared a most interesting Paper by Mr. T. Thorne Baker, A.M.I.E.E., F.C.S., on "The Applications of Electricity to Agriculture," in the course of which he referred to certain experiments that had been conducted, in a small way, with radio-active soil and to the somewhat astonishing results that were said to have been obtained.

As I happened to have in Cornwall a relative living in the neighbourhood where some of these trials were made, I went down in February, 1914,

and had the opportunity of making enquiries on the spot. The particulars I had heard were confirmed, and I was also told the following story :—

“ A year or more ago a local carpenter who had a heap of soil on his premises found it in the way and threw the material over his small allotment garden. This heap had originally come from the ‘dumps’ at the French Radium Mine at Terras, near Truro. It so happened that the soil of this allotment was very poor and never produced good crops. But in the summer following this incident a remarkable improvement in the crops was noticed, and only on trying to account for it did the carpenter recollect throwing down the soil and the source from which it was obtained.” Those are the broad facts of the story as they were told me.

No controlled experiments had, however, been carried out in this country, so far as I am aware, until my Firm undertook the trials described in the following pages, with the object of gaining definite information upon the subject and in the interests of scientific research.

Considerable difficulty was experienced in obtaining either radio-active Ores, or Residues after Radium had been extracted, but I was eventually able to secure several hundredweights of each.

Various vegetables and flowering plants were experimented with, the series comprising some 600 pots and boxes. In most cases the trials were divided into two sections ; the radio-active Ore or Residue being thoroughly incorporated with the soil in half the number, and placed in a layer at the bottom of the pots or boxes in the remainder.

The radio-active materials used were :—

Radio-active Ore certified to contain approximately 8 milligrammes of Radium Bromide per ton of Ore.

Radio-active Ore (from a different source to above) certified to contain approximately 9 milligrammes of Radium Bromide per ton of Ore.

Mine Residue after Radium had been extracted, but certified to still contain 1.8 milligrammes of Radium Bromide per ton.

Black Oxide of Uranium.

To ensure accuracy in the comparative tests, equal conditions were maintained by sowing, planting and watering each set of trials on identical dates.

At a demonstration held at Reading on August 6, 1914, the results secured to date were explained, and a preliminary paper was issued for the use of those present.

In the following pages are given complete particulars both of the experiments undertaken and the conclusions arrived at, as a result of the summer's work. All that has been attempted so far is to ascertain :—

(1) Whether radio-activity has a harmful or beneficial effect upon plant life ;

(2) Whether, if beneficial, strong or weak dressings of radio-active Ore should be employed ; and

(3) Whether radio-active material can be used with advantage to accelerate germination.

It is recognised that the whole subject is in its infancy and that only by patient, and possibly prolonged, experiments can scientific data that will prove of value be obtained.

EXPERIMENTS WITH RADIO-ACTIVE ORES AND RESIDUES, ETC.,

carried out at Sutton's Experimental Station, Reading.

EXPERIMENTS WITH RADISHES.

The radio-active Ore used in this series was certified to contain approximately 8 milligrammes of Radium Bromide per ton of Ore.

In order to determine the degree of radio-activity likely to give the best result the Ore was employed in varying quantities, and the proportions are shown by the figures given in the table below. An attempt was also made to ascertain the difference, if any, arising from the two methods adopted (a) by incorporating Ore with the soil, and (b) by placing Ore at the bottom of box, thus avoiding, as far as possible, actual contact with the plants.

Sutton's Scarlet Globe Radish was chosen for these trials, the seed being sown in boxes about three feet square and several inches deep. Ordinary garden soil, to which no manure had recently been added, was used. Four boxes, not dressed with radio-active Ore, served as "controls" and these contained respectively (a) plain soil, (b) soil and farmyard manure, (c) soil and guano, and (d) soil and a complete fertiliser.

The seeds were sown May 26th and the roots lifted June 24th, so that the trials were in growth and under observation for about four weeks. After sowing, the boxes were placed side by side in the open ground and watered at regular intervals with plain water only. In each box ninety-six roots were allowed to mature, the roots and foliage being weighed separately at the time of lifting. Details of the results are given in the following table:—

RADISH TRIALS.

					TOPS.	ROOTS.	TOTAL WEIGHT.		ORDER OF MERIT.
					ozs.	lbs. ozs.	lbs. ozs.		
RADIO-ACTIVE ORE	Control—Plain soil only	...	...	...	8½	0 11½	1 4		Lowest
	" Farmyard Manure (at 15 tons per acre) added to soil	...	...	...	12	0 12	1 8		8th (equal)
	" Guano (at 1 oz. per sq. yard) added to soil	...	...	...	10	0 15	1 9		7th (equal)
	" Complete Fertiliser (at 3 ozs. per sq. yard) added to soil	...	...	...	11	1 0	1 11		5th
	1 part Ore in 12 parts soil	...	...	...	9½	1 2	1 11½		4th (equal)
	Ore mixed in soil	...	...	...	10	1 3	1 13		3rd
	Ore placed at bottom of box	...	...	...					
	1 part Ore in 18 parts soil	...	...	...	9	1 5	1 14		2nd
	Ore mixed in soil	...	...	...	12	1 3	1 15		1st (equal)
	Ore placed at bottom of box	...	...	...					
	1 part Ore in 24 parts soil	...	...	...	8	1 3½	1 11½		4th (equal)
	Ore mixed in soil	...	...	...	8	1 0	1 8		8th (equal)
	Ore placed at bottom of box	...	...	...					
	1 part Ore in 36 parts soil	...	...	...	8½	0 14	1 6½		9th
	Ore mixed in soil	...	...	...	9	1 1	1 10		6th
	Ore placed at bottom of box	...	...	...					
	1 part Ore in 48 parts soil	...	...	...	12	1 3	1 15		1st (equal)
	Ore mixed in soil	...	...	...	9	1 0	1 9		7th (equal)
	Ore placed at bottom of box	...	...	...					

Notes on the Radish Trials are given on the following page.

RADISH—continued.

It will be observed that every box dressed with radio-active Ore gave a greater total weight (roots and foliage) than did the "control" box which contained plain soil only, and that in six instances the produce of the former exceeded that of the "controls" dressed with farmyard manure or fertilisers.

In this connection it is important to remember that Radium is said to possess a life of several thousand years, and for boxes and pots it may therefore prove possible to employ soil once dressed with radio-active material for an indefinite period.

The crops do not indicate conclusively whether better results are secured by mixing the Ore with the soil, or by placing it at the bottom of the box, neither can the correct proportion of Ore to be used be determined, but all the dressings, containing as they did approximately 8 milligrammes of Radium Bromide to the ton, may have been too strong.

EXPERIMENTS WITH LETTUCES.

Here also the radio-active Ore used was said to contain approximately 8 milligrammes of Radium Bromide per ton of Ore.

As in the Radish trials, the Lettuces were grown in boxes in the open ground. Particulars of the "controls" and the proportions of Ore used are given in the accompanying table.

Each box contained twenty-three heads of Sutton's Ideal Lettuce. The plants were put into the boxes May 25th and the heads lifted and weighed July 14th, with the following results:—

LETTUCE TRIALS.

						WEIGHTS.	ORDER OF MERIT.
						lbs.	
RADIO-ACTIVE ORE	Control—Plain soil only					9½	9th
	" Farmyard Manure (at 15 tons per acre) added to soil ...					10¾	5th
	" Guano (at 1 oz. per sq. yard) added to soil					9	11th
	" Complete Fertiliser (at 3 ozs. per sq. yard) added to soil					13¾	1st
	{	1	part Ore in 12 parts soil.	Ore mixed in soil	...	11¼	3rd (equal)
		1	" " " 12 " "	Ore placed at bottom of box...	...	9¾	10th
		1	" " " 18 " "	Ore mixed in soil	...	10	7th
		1	" " " 18 " "	Ore placed at bottom of box...	...	9¾	8th
		1	" " " 24 " "	Ore mixed in soil	...	10½	6th
		1	" " " 24 " "	Ore placed at bottom of box...	...	7¼	13th
		1	" " " 36 " "	Ore mixed in soil	...	8¾	12th
		1	" " " 36 " "	Ore placed at bottom of box...	...	11	4th
		1	" " " 48 " "	Ore mixed in soil	...	12½	2nd
		1	" " " 48 " "	Ore placed at bottom of box...	...	11¼	3rd (equal)

LETTUCE—continued.

During the period of growth it was very difficult to discern much difference between the several lots, so far as the size of the plants was concerned, and the heaviest weights recorded are evidently due to the fact that in certain cases there was greater solidity in the heads.

It will be seen again that most of the boxes containing radio-active Ore gave a greater weight than the "control" box with plain soil. But only four of the former proved heavier than the trial grown with farmyard manure, whilst the box treated with a complete fertiliser produced the heaviest heads of all. Some allowance, however, must be made on account of the extremely dry character of the weather, and this undoubtedly gave farmyard manure, which always contains moisture, an undue advantage.

EXPERIMENTS WITH PEAS.

The tests with Garden Peas were conducted with Ore containing the same amount of Radium Bromide (approximately 8 milligrammes per ton) as used for the trials of Radish and Lettuce, and in similar proportions.

A very dwarf Pea—Sutton's Hundred-fold—was selected, the plants being grown in boxes from seed sown May 12th. To prevent the depredations of birds the trials were carefully netted, and no pods were removed from either lot until harvested, when the seeds gave the following results :—

PEA TRIALS.

		WEIGHT OF SEED.	ORDER OF MERIT.
		OZS.	
RADIO-ACTIVE ORE	Control—Plain soil only	2	7th
	" Farmyard Manure (at 15 tons per acre) added to soil ...	3½	2nd (equal)
	" Guano (at 1 oz. per sq. yard) added to soil ...	3	3rd (equal)
	" Complete Fertiliser (at 3 ozs. per sq. yard) added to soil ...	4¼	1st
	1 part Ore in 12 parts soil. Ore mixed in soil... ..	3	3rd (equal)
	I " " " 12 " " Ore placed at bottom of box... ..	3½	2nd (equal)
	I " " " 18 " " Ore mixed in soil... ..	3	3rd (equal)
	I " " " 18 " " Ore placed at bottom of box... ..	2¾	4th (equal)
	I " " " 24 " " Ore mixed in soil... ..	3½	2nd (equal)
	I " " " 24 " " Ore placed at bottom of box... ..	2½	5th
	I " " " 36 " " Ore mixed in soil... ..	2¼	6th
	I " " " 36 " " Ore placed at bottom of box... ..	3	3rd (equal)
	I " " " 48 " " Ore mixed in soil... ..	3	3rd (equal)
	I " " " 48 " " Ore placed at bottom of box... ..	2¾	4th (equal)

The table shows that a heavier weight was obtained from each of the boxes dressed with radio-active Ore and with manures than from the plain-soil "control," but the best result was given by the box treated with the complete fertiliser.

EXPERIMENTS WITH TALL NASTURTIUMS.

In this series the radio-active Ore contained approximately 9 milligrammes of Radium Bromide per ton of Ore and was obtained from a different source to that experimented with in the tests already described. Mine Residue after Radium had been extracted, but still retaining 1.8 milligrammes of Radium Bromide per ton, was also used. These trials embraced a much wider variation in the proportion of Ore or Residue allocated to the various lots, and ranged from 1 in 14 to 1 in 2,240, the latter being equivalent to 1 lb. of radio-active material to 1 ton of soil.

Large pots, partly sunk in the ground, were employed. Each set consisted of four pots, four plants to a pot, making sixteen Nasturtiums in each section. When the plants commenced to run they were staked with small pea sticks.

Details of the "control" pots and the proportions of Ore, etc., used are given below :—

Control—Plain soil only.				
" Farmyard Manure (at 15 tons per acre) added to soil.				
" Guano (at 1 oz. per sq. yard) added to soil.				
RADIO-ACTIVE ORE	{	1 part Ore in	14 parts of soil.	Ore mixed in soil.
		1 " "	14 " "	Ore placed at bottom of box.
		1 " "	28 " "	Ore mixed in soil.
		1 " "	28 " "	Ore placed at bottom of box.
		1 " "	56 " "	Ore mixed in soil.
		1 " "	56 " "	Ore placed at bottom of box.
		1 " "	112 " "	Ore mixed in soil.
		1 " "	112 " "	Ore placed at bottom of box.
		1 " "	224 " "	Ore mixed in soil.
		1 " "	224 " "	Ore placed at bottom of box.
		1 " "	448 " "	Ore mixed in soil.
		1 " "	448 " "	Ore placed at bottom of box.
		1 " "	2,240 " "	Ore mixed in soil.
		1 " "	2,240 " "	Ore placed at bottom of box.
RESIDUE	{	1 " Residue in 14	" "	Ore mixed in soil.
		1 " "	14 " "	Ore placed at bottom of box.
		1 " "	28 " "	Ore mixed in soil.
		1 " "	28 " "	Ore placed at bottom of box.
		1 " "	56 " "	Ore mixed in soil.
		1 " "	56 " "	Ore placed at bottom of box.
		1 " "	112 " "	Ore mixed in soil.
		1 " "	112 " "	Ore placed at bottom of box.
		1 " "	224 " "	Ore mixed in soil.
		1 " "	224 " "	Ore placed at bottom of box.
		1 " "	448 " "	Ore mixed in soil.
		1 " "	448 " "	Ore placed at bottom of box.
		1 " "	2,240 " "	Ore mixed in soil.
		1 " "	2,240 " "	Ore placed at bottom of box.

From the outset it was noticed that the two sections dressed respectively with farmyard manure and guano showed the most vigorous growth, the latter also bearing the largest leaves. In the matter of earliness to flower, there was really no difference to be seen, but in the amount of blossom produced, the radio-active Ore, 1 in 14, appeared to yield the most. During the later stages it was difficult to find any distinction between the several lots treated

NASTURTIUM—continued.

with Ore or Residue, although the farmyard manure and guano sections still remained the most vigorous in growth. In this connection see note under Lettuce concerning farmyard manure, page 5.

Some experiments on Tomatoes and other subjects were commenced with Ore and Residue from the same source as that used for the Nasturtiums, but as the material was received very late in the season the trials could not be completed.

EXPERIMENTS WITH BLACK OXIDE OF URANIUM ON FLOWERING ANNUALS.

As only a very small quantity of the above material was available, the trials with it were necessarily limited in number.

Four flowering annuals—African Marigold, *Calendula officinalis* (Pot Marigold), *Dimorphotheca*, and Mignonette—were grown, six pots of each subject being tested in each of the four sections stated below, making a total of ninety-six pots:—

Control—Plain soil only.

Black Oxide of Uranium (1 part in 2,000 parts of soil).

Complete Fertiliser (at 8 ozs. to 40 lbs. of soil).

Complete Fertiliser and Oxide of Uranium mixed (same proportions as above).

In every case where it was used, the action of the Oxide of Uranium appeared to retard flowering, and to affect the foliage and growth much in the same manner as a nitrogenous manure.

The best results were obtained from the mixture of Uranium and complete fertiliser.



"Control"
plain soil only.

Oxide of Uranium
and soil.

Complete Fertiliser
and soil.

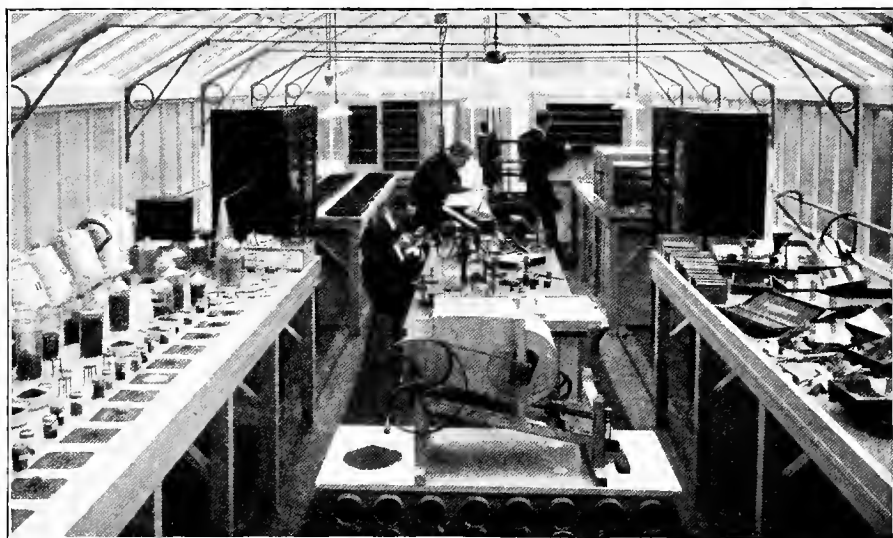
COPYRIGHT

Specimens of the Trials with Flowering Annuals.

GERMINATION TESTS

WITH

RADIO-ACTIVE ORES AND RESIDUES.



COPYRIGHT

These tests were carried out with a view to ascertaining what effect, if any, the Ores would have on the growth of seeds in the laboratory under artificial conditions, and the late autumn was chosen as a suitable period, because seeds germinate less satisfactorily at that time than at any other season of the year.

Red Clover and Smooth-stalked Meadow Grass were selected as representative subjects, and the tests were systematically and carefully conducted, as the tables on the following pages indicate.

The results are negative rather than positive, and generally speaking the "controls" have furnished the best records. This is especially the case in Series A (pot trials) and Series B. On the whole it must be conceded that further investigation is essential before arriving at any definite conclusions.

Laboratory Germination Tests with Radio-Active Ores and Residues.

The Ore was certified to contain approximately 9 milligrammes of Radium Bromide per ton, and the Residue 1·8 milligrammes of Radium Bromide per ton. These materials were incorporated with plain soil in the proportions indicated by the figures given in the accompanying tables.

SERIES A.

Red Clover seed tested in pots (48-size). Seeds sown November 23rd, 1914. 100 seeds to each test. Temperature 68° Fahr.

Trial No.		Days.																														Total per cent. germination.	Note. Three weeks allowed for the completion of tests and "hard" seeds can be shown. A slow method compared with Series B and results not so good.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		
1	Control—plain soil only ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	86		
2	1 part Ore in 28 parts soil ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	85		
3	112 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	83		
4	1 " 448 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	81		
5	1 " 2,240 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	84		
6	1 " Residue in 28 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	65		
7	1 " 112 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	84		
8	1 " 448 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	82		
9	1 " 2,240 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	82		

The Germination Tables are continued on pages 10 to 13.

SERIES B.

Red Clover seed tested in cold germinator on single sheets of filter paper, the Ore or Residue resting on same paper, but not touching seed. Temperature 68° Fahr. Seed sown on November 23rd, 1914. 100 seeds to each test. Fifteen days were allowed in Series B, C, D and E.

Trial No.		Days.															Total per cent. germination.	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
10	Control—filter paper only	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	98 x 1	Note. The usual method of conducting laboratory tests of Clovers. The "control" gives the quickest and ultimately the best result of this series.
11	1 part Ore in 28 parts soil	...	...	69	13	4	1	3	5	4	2	...	...	...	s	1	88 x 4	
12	1 " " 112	...	...	63	13	4	1	5	5	1	...	...	...	...	...	...	32 x 6	
13	1 " " 448	...	...	57	18	6	3	5	...	...	...	...	...	...	...	...	83 x 2	
14	1 " " 2,240	...	...	61	16	6	3	...	...	...	...	...	...	...	...	...	84 x 4	
15	1 " " Residue in 28	...	...	50	14	4	3	5	7	1	...	...	...	...	...	...	87 x 4	
16	1 " " 112	...	...	49	21	4	3	5	3	1	...	...	...	...	...	...	86 x 6	
17	1 " " 448	...	...	62	17	4	...	5	2	1	...	...	...	...	...	...	86 x 4	
18	1 " " 2,240	...	...	51	19	2	3	5	...	...	...	...	...	...	...	...	89 x 2	

SERIES C.

Red Clover seed tested in cold germinator on sheet of filter paper, the Ore or Residue being directly underneath on a lower sheet of filter paper. Temperature 68° Fahr. Seed sown on November 23rd, 1914. 100 seeds to each test.

Trial No.		Days.															Total per cent. germination.	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
19	Control—2 filter papers	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	92 x 2	Note. These results approximate fairly closely to Series B, the sheet of paper separating the Ore or Residue from the seed having had little, if any, effect.
20	1 part Ore in 28 parts soil	...	...	58	15	5	1	3	5	4	...	...	...	...	...	...	82 x 2	
21	1 " " 112	...	...	58	14	1	2	5	...	...	...	...	...	...	...	...	82 x 2	
22	1 " " 448	...	...	66	10	2	4	5	1	1	...	...	...	...	...	...	88 x 4	
23	1 " " 2,240	...	...	56	17	3	8	5	1	1	...	...	...	...	...	...	89 x 4	
24	1 " " Residue in 28	...	...	53	12	4	5	5	3	...	...	...	...	...	...	...	81 x 4	
25	1 " " 112	...	...	60	15	4	1	5	6	...	...	...	...	...	...	...	90 x 6	
26	1 " " 448	...	...	60	10	4	3	5	2	3	...	...	...	...	...	...	85 x 5	
27	1 " " 2,240	...	...	60	15	5	5	5	4	...	...	...	...	...	...	...	91 x 2	

SERIES D.

Red Clover seed tested in cold germinator on two sheets of filter paper, with the Ore or Residue beneath, resting on one sheet of zinc. Temperature 68° Fahr. Seed sown on November 23rd, 1914. 100 seeds to each test.

Trial No.		Days.																														Total per cent. germination.	Note.	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30			
28	Control—2 filter papers and 1 zinc sheet	...	...	...	61	8	5	4	s	2	4	1	1	1	1	s	2																89 x 10	The number of germinating seeds in this test is much the same as in Series B and C, but in view of the far larger proportion of seeds which swelled, but the radicles of which failed to pierce the seed coat, it is fair to assume that, had the test been prolonged beyond the regulation period of 15 days, a greater percentage of germinating seeds would have been obtained. Possibly the tardiness of certain seeds was due to the presence of zinc. While it is notorious that samples taken from the same bulk vary in a remarkable degree for no apparent reason, it is a fact worth recording that this sample exhibited a far greater total energy than did either Series B or C.
29	1 part Ore in 28 parts soil	...	...	...	50	14	4	3	s	5	3	1	2	1	1	s	...																84 x 8	
30	1 " 112 "	...	...	...	62	16	8	2	s	1	1	1	...	1	1	s	...																91 x 7	
31	1 " 448 "	...	...	...	50	19	6	3	s	6	1	1	...	1	1	s	2																92 x 5	
32	1 " 2,240 "	...	...	...	46	22	7	5	s	8	...	...	...	1	1	s	...																90 x 9	
33	1 " Residue in 28 "	...	...	...	45	19	6	3	s	5	1	2	2	...	...	s	1																84 x 14	
34	1 " 112 "	...	...	...	58	16	8	...	s	7	1	3	1	1	1	s	2																97 x 2	
35	1 " 448 "	...	...	...	48	21	5	4	s	5	...	3	3	1	...	s	...																90 x 10	
36	1 " 2,240 "	...	...	...	37	29	7	1	s	6	1	1	2	...	2	s	4																90 x 5	

SERIES E.

Red Clover seed tested in cold germinator on two sheets of filter paper, the Ore or Residue being between two sheets of zinc placed immediately under the filter paper. Temperature 68° Fahr. Seed sown on November 23rd, 1914. 100 seeds to each test.

Trial No.		Days.																			Total per cent. germination.	NOTE.												
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19			20	21	22	23	24	25	26	27	28	29	30	
37	Control—2 filter papers and 2 zinc sheets	...	...	...	58	17	10	2	s	...	...	...	...	1	1	...	s	...														89 x 9	The proportion of germinating seeds in this trial is not so good as in Series D, but otherwise the note appended to the latter applies here also. It is interesting that while on the 3rd, 4th and 5th days a larger number of seeds germinated in this Series than in Series D, the proportion of seeds which swelled but failed to actually germinate is considerably larger than in Series D. This latter feature may be due to the presence of a second sheet of zinc.	
38	1 part Ore in 28 parts soil	...	...	...	49	21	10	2	s	3	2	2	1	1	1	...	s	...															91 x 9	
39	1 " 112 "	...	...	...	51	15	8	4	s	4	1	1	1	1	1	...	s	...															86 x 10	
40	1 " 448 "	...	...	...	45	25	7	3	s	...	...	...	...	...	...	...	s	1															92 x 5	
41	1 " 2,240 "	...	...	...	51	22	7	...	s	...	2	1	1	...	...	...	s	...															84 x 18	
42	1 " Residue in 28 "	...	...	...	42	21	7	5	s	5	...	1	1	1	...	s	2																84 x 12	
43	1 " 112 "	...	...	...	54	17	5	1	s	4	1	1	1	2	...	s	2																88 x 9	
44	1 " 448 "	...	...	...	59	15	2	1	s	4	1	1	6	1	...	s	...																88 x 11	
45	1 " 2,240 "	...	...	...	43	24	5	3	s	7	3	1	2	...	...	s	...																88 x 9	

Note.—SERIES F and SERIES G, tested under the alternating system : 8 hours each day at 86° Fahr. and 16 hours at 68° Fahr. Thirty days allowed. Seed sown on November 23rd, 1914. 100 seeds to each test.

SERIES F.

Smooth-stalked Meadow Grass seed tested on single sheets of filter paper, the Ore or Residue resting on same paper, but not touching seed.

Trial No.		Days.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Total per cent. germination.	Note.
46	Control—filter paper only	..	..	..	..	..	..	..	s 20	6	9	7	8	6	s 14	3	1	5	4	..	..	..	..	..	..	..	..	..	..	..	..	..	87	As in the corresponding test with Red Clover, (filter paper only) the "control" gives the best result, although there is no striking difference in any of the totals recorded in Series F. Neither the Ore nor the Residue appears to have assisted germination.
47	1 part Ore in 38 parts soil	..	..	..	..	..	..	..	s 22	7	6	3	2	4	s 7	8	5	6	1	..	..	..	..	..	..	..	..	..	..	..	..	..	80	
48	1 " " 112 "	..	..	..	..	..	..	..	s 21	8	4	8	6	4	s 8	9	4	3	1	..	..	..	..	..	..	..	..	..	..	..	..	..	84	
49	1 " " 448 "	..	..	..	..	..	..	..	s 20	10	5	6	4	9	s 6	4	5	3	3	1	..	..	..	..	..	..	..	..	..	..	..	..	82	
50	1 " " 2,240 "	..	..	..	..	..	..	..	s 22	8	1	2	6	2	s 11	2	7	6	2	1	..	..	..	..	..	..	..	..	..	..	..	..	80	
51	1 " Residue in 28 "	..	..	..	..	..	..	..	s 22	8	5	5	6	5	s 7	12	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	83	
52	1 " " 112 "	..	..	..	..	..	..	..	s 19	4	5	6	7	7	s 13	10	2	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	85	
53	1 " " 448 "	..	..	..	..	..	..	..	s 10	4	7	10	2	2	s 14	8	3	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	83	
54	1 " " 2,240 "	..	..	..	..	..	..	..	s 20	4	3	9	5	2	s 13	3	3	1	3	2	s 2	..	..	..	..	..	..	..	..	..	..	..	..	82

SERIES G.

Smooth-stalked Meadow Grass seed tested on sheet of filter paper, the Ore or Residue being directly underneath on a lower sheet of filter paper.

Trial No.	Days.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Total per cent. germination.
55	Control—2 filter papers	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	80
56	1 part Ore in 38 parts soil	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	82
57	1 " " 112 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	90
58	1 " " 448 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	81
59	1 " " 2,240 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	82
60	1 " Residue in 28 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	82
61	1 " " 112 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	83
62	1 " " 448 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	85
63	1 " " 2,240 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	85

Note.

With the exception that the "control" gives the lowest return, instead of the highest, the figures in this Series approximate closely to those in Series F.

Note.—SERIES H and SERIES I, tested under the alternating system: 8 hours each day at 86° Fahr. and 16 hours at 68° Fahr. Thirty days allowed. Seed sown on November 23rd, 1914. 100 seeds to each test.

SERIES H.

Smooth-stalked Meadow Grass seed tested on two sheets of filter paper, with the Ore or Residue beneath, resting on one sheet of zinc.

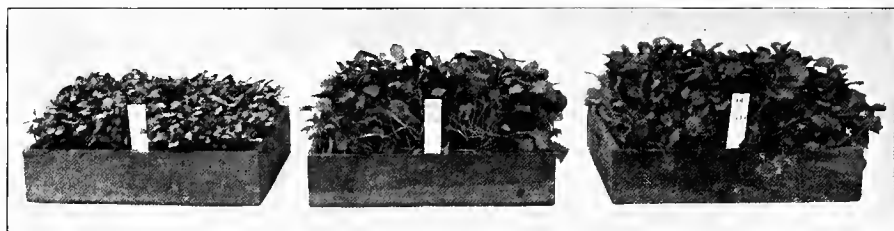
Trial No.		Days.																														Total per cent. germination.	Note.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		
64	Control—2 filter papers and 1 zinc sheet	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	81	It is noteworthy that in this and the following Series the zinc seems to have affected the energy of the growth during the early days. Possibly this was due to the over-temperature caused by its presence. In the later stages germination improved, and it is probable that with more time the final results would have equalled Series F and G.
65	1 part Ore in 28 parts soil	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	80	
66	1 " " 112 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	80	
67	1 " " 448 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	82	
68	1 " " 2,240 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	81	
69	1 " " Residue in 28 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	81	
70	1 " " 112 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	81	
71	1 " " 448 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	83	
72	1 " " 2,240 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	78	

SERIES I.

Smooth-stalked Meadow Grass seed tested on two sheets of filter paper, the Ore or Residue being between two sheets of zinc, placed immediately under the filter paper.

Trial No.		Days.																														Total per cent. germination.	Note.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		
73	Control—2 filter papers and 2 zinc sheets	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	66	Here the retarding of growth (caused apparently by the additional piece of zinc) is still more pronounced than in Series H.
74	1 part Ore in 28 parts soil	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	81	
75	1 " " 112 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	82	
76	1 " " 448 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	81	
77	1 " " 2,240 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	78	
78	1 " " Residue in 28 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	77	
79	1 " " 112 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	79	
80	1 " " 448 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	77	
81	1 " " 2,240 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	77	

EXPERIMENTS WITH RAPE SEED TO ASCERTAIN EFFECT ON GERMINATION.



COPYRIGHT

"Control"
plain soil only.

One part Residue
to 448 parts soil.

One part Ore
to 448 parts soil.

Some of the Tests with Rape seed. It will be seen that in the boxes dressed respectively with Residue and Ore, growth is much more luxuriant than in the "Control" box.

In order to further ascertain the effects of radio-active Ores and Residues on germination, small boxes were sown with seed of Rape, one of the quickest germinating subjects. No artificial heat was applied, the boxes being stood in a cold frame.

The proportions of Ore and Residue used are stated in the table below :—

Control—Plain soil only.			
RADIO-ACTIVE ORE	"	Farmyard Manure (at 15 tons per acre) added to soil.	
	"	Guano (at about 1 oz. per sq. yard) added to soil.	
	"	Complete Fertiliser (at about 3 ozs. per sq. yard) added to soil.	
	"	1 part Ore in	14 parts of soil.
	1 "	"	28 " "
	1 "	"	56 " "
	1 "	"	112 " "
	1 "	"	224 " "
	1 "	"	448 " "
	1 "	"	2,240 " "
	1 "	Residue in	14 " "
	1 "	"	28 " "
	1 "	"	56 " "
	1 "	"	112 " "
	1 "	"	224 " "
	1 "	"	448 " "
	1 "	"	2,240 " "
RESIDUE			

The trials were carried out in duplicate, the second sowing being made five days after the first. The results of the first experiment were in all cases confirmed by those of the second. It was found that in each of the boxes dressed with Ore or Residue the seed germinated before that in the plain-soil "control" or in the boxes dressed with manures. Further, all the radio-active soil tests germinated equally, except "Ore 1 in 14," which probably indicates that the proportion was too great. Next in order of germination came the plain soil, farmyard manure, complete fertiliser, and guano last. After three weeks' growth it was still noticeable that those trials dressed with artificial manures were the most backward.

The experiment is extremely interesting in that it shows, so far as hastening germination is concerned, the dressing of Residue (containing 1·8 of Radium Bromide per ton) at the rate of 1 lb. to 1 ton of soil, gave results equal to the dressing of Ore (containing approximately 9 milligrammes of Radium Bromide per ton) at the rate of 1 lb. to 14 lbs. of soil, the latter costing many times as much as the former.

SUMMARY OF THE EXPERIMENTS.

IN THE OPEN AIR.

Whilst not pretending that the results of a single season's experiments, embracing only a few subjects, can be considered sufficiently definite to prove the value, or otherwise, of the effects of Radium on plant life in general, the tests enumerated in the foregoing pages afford some evidence that Radium emanations possess the property of developing and increasing growth.

Many of the Radish, Lettuce, and Pea trials which were dressed with radio-active Ore showed considerable superiority over those grown in plain soil, but the cost of the Ore far outweighed the worth of the larger crop. On the other hand, if future investigation conclusively shows that soil once dressed with radio-active material can be used to equal advantage over a period of years (as suggested on page 4), the original outlay would probably be justified.

No material difference in results was apparent between the trials with Ore incorporated with the soil and those with Ore placed at the bottom of the boxes or pots.

The quantity and degree of radio-active material to ensure the best return cannot be definitely stated, but it would appear that a light dressing is likely to give as good results as a larger amount.

In the trials with Rape seed, the influence of the radio-active material in accelerating germination was most consistent in all the tests, but it was evident that a very small quantity of low grade Residue proved as effective as a considerable amount of Ore containing a much larger proportion of Radium.

It is proposed to continue the experiments on modified lines, based on the experience already gained.

IN THE LABORATORY.

In these germinating tests also there is no indication that better results are obtainable with Ore possessing considerable radio-activity than with Residue of low value, nor have these trials generally proved superior to the "controls."

The observations printed opposite each table on pages 9 to 13 speak for themselves, but it should be noted that in Series D and E (Red Clover) a larger proportion of weak and hard seeds were energised to swell, without, however, the radicle breaking through the coat, than in Series B and C (Red Clover). Whether this feature was due, as suggested, to the presence of zinc or not, it is important, and merits further investigation.

Publications issued by Messrs. Sutton & Sons.

Bulletin No. 1. Brassica Crosses.

" " 2. Tuber-bearing Solanums.

" " 3. Experiments in Crossing a Wild Pea from Palestine with Commercial Peas.

" " 4. Results obtained by Crossing a Wild Pea from Palestine with Commercial Types and *Pisum sativum umbellatum*.

" " 5. The Progress in Vegetable Cultivation during Queen Victoria's Reign.

By
ARTHUR W. SUTTON,
F.L.S., V.M.H.

Price 2s. 6d. net
each.

Permanent and Temporary Pastures.

By **MARTIN SUTTON, F.L.S.**

EIGHTH EDITION. Illustrated with 22 beautiful engravings and including 44 Analyses of Natural Grasses, Clovers, etc.

Bound in Cloth. Price 5s.

POPULAR EDITION, omitting the Illustrations and Analyses.

Paper Cover. Price 1s.

The Book of the Links.

A Symposium on Golf by **MARTIN H. F. SUTTON, F.L.S.**

Illustrated with numerous interesting Photographs and Cartoons.

Royal 8vo. Cloth, 10s. 6d. net.

The Culture of Vegetables and Flowers from Seeds and Roots.

By **SUTTON & SONS.**

Fifteenth Edition. Price 5s. net.

Lawns.

By **SUTTON & SONS.**

Twelfth Edition. Beautifully Illustrated. Price 1s.

Sutton's Amateur's Guide in Horticulture.

Containing Descriptive Lists of Vegetables and Flowers; profusely illustrated. Published annually in January.

Price 1s. Post free.

Gratis to regular Customers of 20s. value.

Sutton's Bulb Catalogue.

A Descriptive and Illustrated List of Bulbous Flower Roots, etc. Published annually in August.

Price 6d. Post free. Gratis to Customers for Bulbs.

Sutton's Farmers' Year-Book and Graziers' Manual.

Contains offers of the finest cleaned Grasses and Clovers of the last harvest, and Root Seeds saved from weight-producing pedigree stocks. Published annually in February.

Price 6d. Gratis to Customers.

SUTTON & SONS, READING,

Seedsman By Appointment to His Majesty King George V.

